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Original Article

A Study on the Characteristics of Three Types of Handwriting Sounds for Use in ASMR

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Abstract - *ASMR stands for Autonomous Sensory Meridian Response, a healing content that calms the mind with images and sounds. Among them, ASMR uses sound to stimulate the auditory sense and heal people. This paper studies the sound of handwriting among ASMR sounds. The handwriting sounds vary depending on the writing tool, but the basic, delicate friction sound calms people's minds. The writing tools used for handwriting are very diverse. However, for the study, we studied the writing sounds of three types of representative writing tools commonly used in daily life: pencil, fountain pen, and ballpoint pen. The paper used a comparative analysis method for the study by synthesizing the acoustic characteristics of writing sounds using three writing tools and people's responses and opinions. The study showed that the sound of writing with a pencil provides relaxation and calms people's minds by balancing the friction sound of the pencil lead and paper in the low and high frequency bands. There was an opinion that the sound of writing with a fountain pen emphasizes the high frequency range, which gives people a refreshing stimulation and clears their minds. There was a response that the sound of writing with a ballpoint pen emphasizes the soft low frequency range, which calms people's minds. The overall opinion was that writing suits ASMR because the repeated sound of light rubbing gives people a sense of stability and comfort.*

Keywords - *ASMR, Healing content, Hearing, Handwriting, Writing tools, Pencil writing, Fountain pen writing, Ballpoint pen writing.*

1. Introduction

In this paper, we studied the sound of handwriting using ASMR (Autonomous Sensory Meridian Response) using sound. The fact that ASMR using sound is continuously developing proves that sound greatly influences modern people, but that the stress that modern people receive in their social lives is increasing. In addition, ASMR sound is called healing sound because it uses sound to make people feel comfortable. In short, ASMR using sound can be said to be a method of self-comfort through hearing. As a research method for the sound of handwriting among ASMR sounds, acoustic analysis, MOS test, and interview were conducted. Since the sound characteristics of handwriting sound vary depending on the writing tool, selecting writing tools is important to capture the sound of writing. The writing tools for studying the sound of handwriting were generally pencils, fountain pens, and ballpoint pens, frequently used daily. In order to record the handwriting sounds for the study, a digital condenser microphone that can guarantee delicate recording quality was used, and a quiet studio booth was selected to record the three writing sounds. Acoustic analysis was performed by comparing the acoustic characteristics of the three handwriting sounds and reflecting the opinions of listeners responding to the handwriting sounds through MOS tests and interviews. The recorder used to record the three handwriting sounds was a digital recorder H2 from ZOOM Corporation, and the tool for acoustic analysis was Adobe's Audition program. The listeners for the MOS test and interviews were five ordinary people [1, 2].

2. What is ASMR?

ASMR is an abbreviation for Autonomous Sensory Meridian Response. It is a term that refers to a sensory experience, such as psychological stability or pleasure, that appears in response to visual, auditory, tactile, olfactory, or cognitive stimulation. Auditory ASMR sounds have been used worldwide for decades in sound-based psychotherapy. Then, in 2010, the term ASMR became established in the United States and Australia and is also called “whisper therapy.” ASMR is introduced through various platforms such as podcasts and YouTube. The most common ASMR sound trigger can be considered to be a type of sound that is small, repetitive, and refreshingly stimulating. In particular, ASMR sounds provide stability, comfort, and even pleasure to people who are psychologically anxious or who want to be comforted in any way. For example, whispering, scratching, or rustling sounds can be said to be ASMR sound triggers. Some people feel the sound of tapping something softly or crumpling paper

as triggers, while others feel the sound of nature, such as rain, wind, or waves. Among them, those with a unique passion for ASMR sounds develop new ASMR sounds, such as creating sounds similar to the sound felt when cleaning the inside of the ear. They also record such sounds with multiple microphones at various angles to create so-called 3D sounds or upload videos of these types of ASMR sound triggers to YouTube [3, 4, 5].

3. A Study on Three Types of Handwriting Sounds Among ASMR

ASMR sounds vary, including loud, soft, and whispering sounds. However, ASMR cannot use sounds classified as noise, and it must be sounds that can be accepted as comfortably as possible. The most common ASMR sound characteristics are small, repetitive, fresh, and softly stimulating. rom that perspective, this paper selected and studied the sound of handwriting, which is a representative sound among ASMR sounds. The sound of handwriting has its characteristics depending on the writing tool. In this paper, we studied the sound of handwriting using pencils, fountain pens, and ballpoint pens, commonly used writing tools in everyday life. As a research method, we analyzed the acoustic characteristics of the three handwriting sounds depending on the writing tool and collected people's reactions and opinions through MOS tests and interviews for each writing sound. [6, 7] Figure 1 shows three representative writing tools among various writing tools used in real life: pencils, fountain pens, and ballpoint pens. A pencil is a writing tool that allows writing by inserting a lead made by mixing an appropriate amount of charcoal and viscosity between wood. Pencils are primarily divided into hardness (Hard) and density (Black), with a firmness level in the middle. Pencil units are divided into 17 units (9H, 8H, 7H, 6H, 5H, 4H, 3H, 2H, H, F, HB, B, 2B, 3B, 4B, 5B, 6B) from 6B to 9H. Among them, HB, B, and 2B pencils are mainly used for writing in real life, and 4B pencils are mainly used for sketching in art classes. For the research, a B unit pencil with an intermediate level of hardness and density was used. The next writing tool, the fountain pen, has the longest history among writing tools. The fountain pen is an improved version of the pen, which was used by hanging the nib on a tree and frequently dipping it in ink. It was improved from the method of writing by dipping it in ink to using it by putting the ink in a tube and letting it flow down. Fountain pens are also divided into the spare type, where the ink tube is replaced. The pump type where the nib is inserted into an ink bottle and sucked up, and the suction type where the ink is poured in.

A pump type fountain pen that is readily available on the market was used for the research. A ballpoint pen is a writing tool that contains ink in a small plastic or iron tube. It rolls the ball installed at the end to release ink so that letters can be written. The purpose of a ballpoint pen is largely divided into water-based and oil-based depending on the composition of the ink, and the specifications of a ballpoint pen are divided according to the size of the ball, usage time, and usage distance. The ballpoint pen used for the study was the Monami 153 ballpoint pen, which is used for general writing. The Monami 153 ballpoint pen has a medium-sized ball size of about 1 mm, can be used for about 8 hours, and can be used for about 600 meters [7, 8].

3.1. Acoustic Analysis of Three Types of Handwriting Sounds

Acoustic analysis is based on the three elements of sound. Acoustic analysis includes time domain analysis, spectrogram analysis, and spectrum analysis. Time domain analysis analyzes the size and continuity of sound, spectrogram analysis analyzes the energy of each pitch, and spectrum analysis analyzes the characteristics of tone by frequency band. The tool for acoustic analysis of handwriting sound was Adobe's Audition program. The size and continuity of sound are analyzed as a time domain waveform, sound components and energy are analyzed as a spectrogram, and the distribution of sound by the band and overall frequency characteristics are analyzed as a spectrum. The analysis of these frequency components obtains the result value using the FFT concept.

(a) Pencil **(b) Fountain pen** **(c) Ballpoint pen**

Fig. 1 Three types of writing instruments

"사랑하는 사람에게 마음을 담아 손편지를 써 보세요."

"Write a handwritten letter to your loved one with your heart."

Fig. 2 Handwritten content

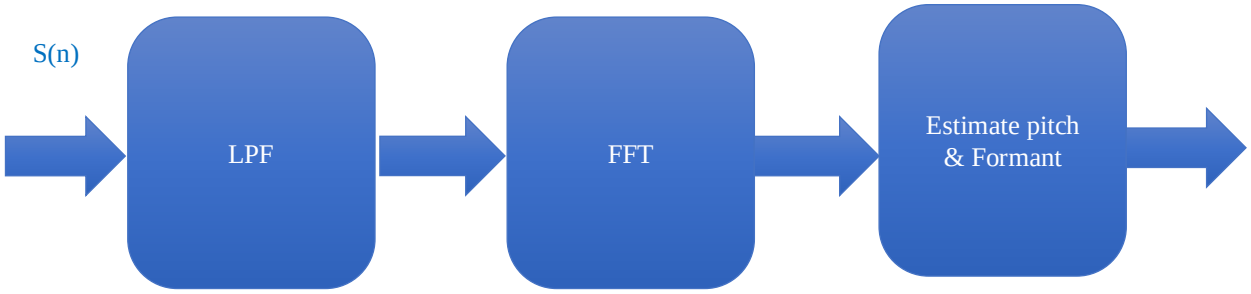
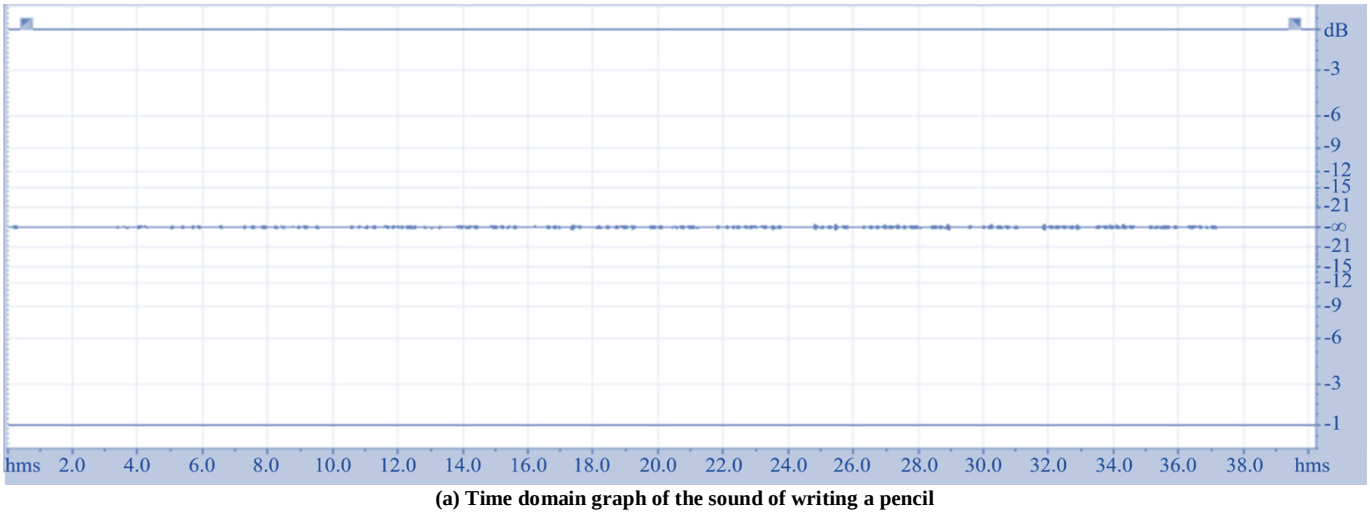


Fig. 3 FFT diagram for obtaining sound information

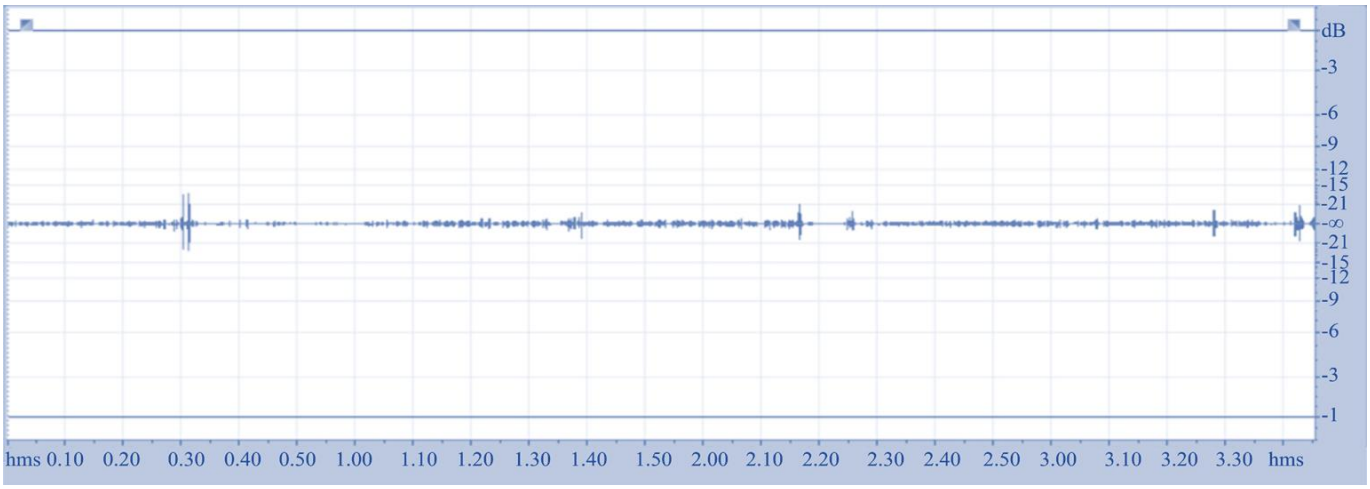
Figure 3 is a diagram of the process of digitizing an analog audio signal using a Fast Fourier Transform (FFT). The first step in digitizing an analog signal is to perform a low-pass filtering operation (LPF: Low Pass Filter) that passes low-frequency signals while filtering out the noise in large quantities in high frequencies. Next, the audio signal is converted to be easy to analyze using a fast Fourier transform. This process establishes a foundation for analyzing the pitch and formant of the audio frequency.

3.1.1. Time Domain Analysis

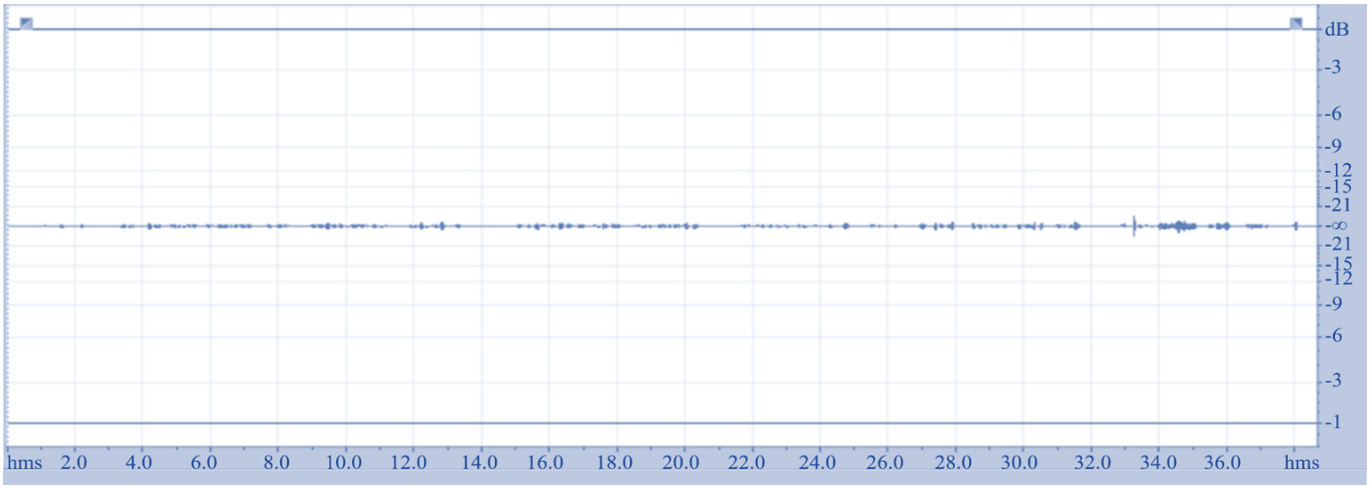
As the first step for the acoustic analysis of three handwriting sounds among ASMR sounds, time domain analysis was performed. Time domain graphs were derived in the order of pencil, fountain pen, and ballpoint pen handwriting sounds from the three handwriting sounds. In the time domain graph, the time-dependent energy of the handwriting sound components was analyzed, and the continuity and continuity were analyzed to obtain the results [9].



(a) Time domain graph of the sound of writing a pencil



(b) Time domain graph of the sound of writing a Fountain pen



(c) Time domain graph of the sound of handwriting a ballpoint pen

Fig. 4 Time-domain graphs for three handwriting sounds

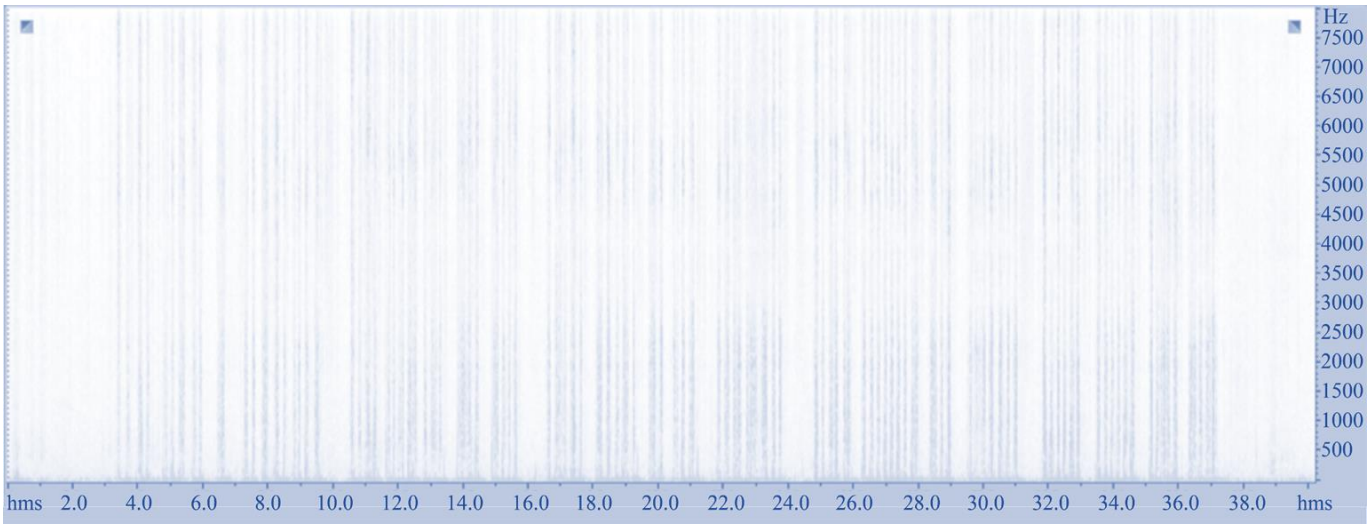
Figure 4 is a time domain graph of three handwriting sounds, and all of a, b, and c show typical characteristics of handwriting sounds. The time domain graph of the sound of writing a pencil shows that the friction between the pencil lead made of coal and clay and the paper is expressed as a thin solid line. The fact that the sound of writing a pencil is depicted as a thin solid line indicates that the sound is slight and continues delicately. In other words, the sound of writing a pencil is a sound that is transmitted continuously, like a gentle whisper.

Looking at the time domain graph of the sound of writing a fountain pen in b, you can see that the solid lines are slightly clearer and thicker than the sound of writing a pencil. The sound of writing a fountain pen is the sound of writing by continuously scraping the paper with a sharp pen tip, so the pencil lead made of coal and clay creates a slightly sharper friction sound than the sound of friction against the paper. Also, some parts are expressed roughly here and there, which seem to be expressed when the fountain pen tip touches the ground hard. If you look at the time domain graph of the sound of writing a ballpoint pen in c, you can see that the continuous solid line graph, a handwriting characteristic, is expressed. However, it shows a thinner solid line than the pencil writing and somewhat thick lines here and there.

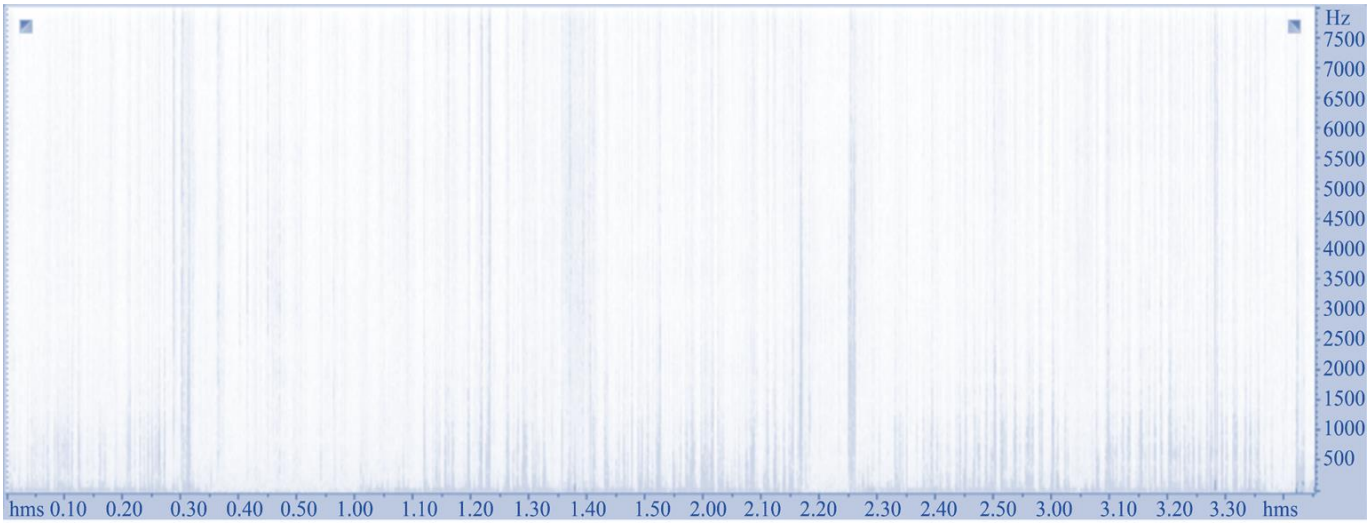
It is noticeably thinner than the fountain pen writing sound in b, but it is similar in that it is depicted with irregular solid lines here and there. It is judged that ballpoint pen writing is expressed more weakly because the softball of the ballpoint pen makes a friction sound against the ground as it rolls, and the expression of touching the ballpoint pen to the ground again every time a new word is written in the middle of a sentence is expressed in bold here and there.

3.1.2. Spectrogram Analysis

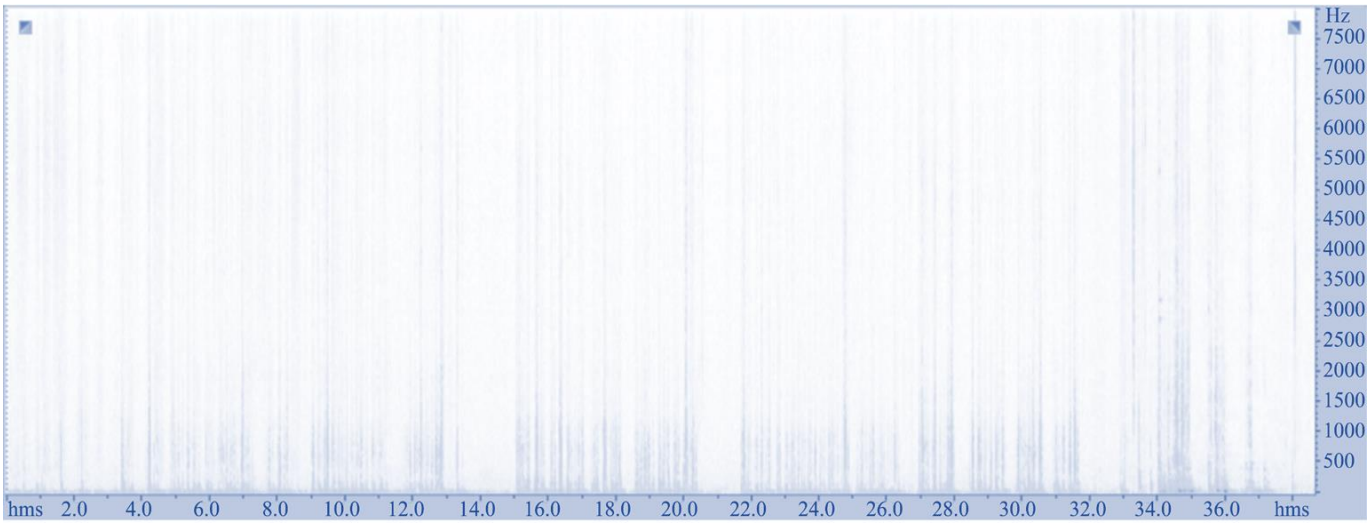
In order to analyze the sound energy of the three handwriting sounds, the spectrogram graph was analyzed. In the spectrogram analysis method, each input writing sound was converted to digital and the energy of each frequency component was measured [1].



(a) Spectrogram graph of the sound of writing a pencil



(b) Spectrogram graph of the sound of writing a Fountain pen



(c) Spectrogram graph of the sound of writing a ballpoint pen

Fig. 5 Spectrogram graphs for three types of handwriting sounds

The spectrogram graph of the pencil writing sound in Figure 5 a shows that thin and long graphs are densely arranged like rain. The pencil writing sound frequency is expressed as a thin and dense vertical line graph with an even thickness across the entire band because the pencil writing sound regularly generates soft friction sounds. The spectrogram graph of the fountain pen writing sound in b also shows a thin and long graph, a characteristic of the writing sound. The pencil writing sound is expressed as thin but even thick across the entire band. However, the fountain pen writing sound has strong frequency energy below 1,500 Hz and somewhat weaker but evenly distributed energy in the frequency range above 1,500 Hz. In addition, you can see vertical solid lines frequently expressed strongly across the entire band, which seem to represent the fountain pen tip contacting the ground when starting to write a new letter. Looking at the shape shown in the spectrogram graph of the sound of ballpoint pen writing in c, the thin and long graph, which is a characteristic of the sound of handwriting, is expressed thinner overall compared to the sound of pencil writing in a and the sound of fountain pen writing in b. In addition, the frequency energy below 1,000 Hz appears strong, and the entire band above 1,000 Hz is evenly distributed with relatively thin energy. In addition, occasionally, a strong vertical solid line is expressed as in the sound of fountain pen writing. This phenomenon does not appear in pencil writing, and it is thought to be a phenomenon that occurs when the fountain pen nib or ballpoint pen ball lifts off the ground and then touches it again each time each letter is written.

3.1.3. Spectrum Analysis

Through spectrum analysis of the three handwriting sounds, we investigated each handwriting sound's frequency distribution and sound component characteristics. Spectral analysis can determine what kind of graph each handwriting sound shows within the audible frequency band and what kind of frequency band it is distributed in [4, 10].

First, in the graph of the pencil writing sound in the graph of Figure 6, the graph of a has a low-frequency band that is moderately high and parallel, then gradually decreases from 2,300 Hz to 3,000 Hz, reaches a plateau until 4,100 Hz, and then rises again, forming a flat graph across the entire high-frequency band from 4,800 Hz. This graph tells us that the pencil writing sound is a sound that is continuously generated like a whisper and is a sound that is not stimulating but rather focused, putting people's minds at ease. The graph of the fountain pen writing sound in b shows a graph in which the low-frequency band below 800 Hz appears strongly, then decreases to 2,800 Hz and gradually rises toward the high-frequency range, and shows a slope that gradually decreases starting from 6,000 Hz. The sound of b's fountain pen writing is higher in the low-frequency range below 1,500 Hz than the sound of pencil writing, but it is low from 1,500 Hz to 3,000 Hz, high from 3,000 Hz to 4,500 Hz, and similarly formed throughout the high-frequency range from 4,500 Hz. From this, we can see that the sound of B's fountain pen writing gives people a soft feeling, like ballpoint pen writing, and is cooler than pencil writing.

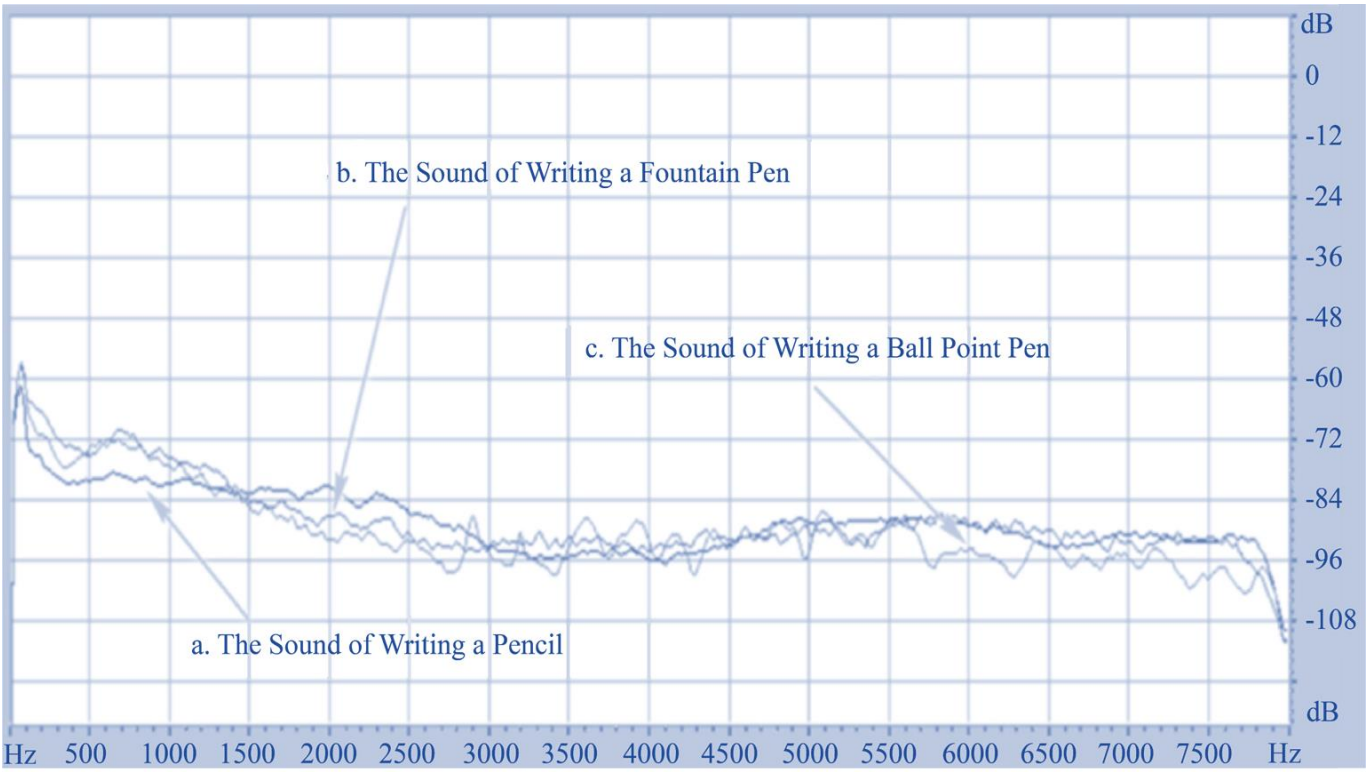


Fig. 6 Spectrum graphs for three handwriting sounds

Table 1. MOS test and comments for three handwriting sounds

Listener	The sound of writing a pencil					The sound of writing a fountain pen					The sound of writing a ballpoint pen					Interview comments
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Listener 1					O				O			O				The sound of pencil writing is appropriately fricative.
Listener 2				O						O		O				The sound of a fountain pen's writing is refreshing with its friction.
Listener 3					O				O				O			The sound of writing with a pencil is nice because it is a uniform friction sound.
Listener 4				O					O						O	The sound of writing with a ballpoint pen is soft.
Listener 5			O							O			O			The sound of writing with a fountain pen is refreshing.

The graph of c's ballpoint pen writing sound shows a similar graph to that of the fountain pen writing sound in the low-frequency range below 2,700 Hz, but the full-band graph heading toward the high frequency above 2,700 Hz is lower and parallel than the sounds of a's pencil writing and b's fountain pen writing but is expressed with somewhat rough peaks and valleys. The sound of C's ballpoint pen writing is expressed with a heavy low frequency range and a weak high frequency range, showing an overall soft sound characteristic, which can be seen in the fact that it conveys a calm and soft feeling to people.

3.2. MOS Test and Comments for Three Handwriting Sounds

The MOS test (MOS Test: Means Opinion Score Test) is a simple survey method mainly used for call quality testing. The MOS test is an opinion verification test whose reliability has been verified by allowing objective and sincere opinions to be expressed even if the number of subjects is small. Recently, it has been used to survey people's opinions in various fields. This study also used the MOS test to determine the characteristics of three handwriting sounds. The MOS test on handwriting sounds was conducted to collect the opinions of listeners who listened to and responded to the sounds of handwriting with a pencil, fountain pen, and ballpoint pen, respectively. Five listeners were surveyed on how each handwriting sound affected the human body for the MOS test. For each sound, 5 points were given if it felt very good, 4 points if it felt just good, 3 points if it felt average, 2 points if it felt bad, and 1 point if it felt very bad. In addition, opinions were heard on the sound that received the highest score [3, 11, 12]. The MOS test results showed that the pencil writing sound scored 5 points for 2 people, 4 points for 2 people, and 3 points for 1 person, for a total score of 21 points. The fountain pen writing sound received 22 points, with 2 people receiving 5 points and 3 people receiving 4 points, for a total score of 22 points. The sound of writing with a ballpoint pen received 15 points, with 1 person receiving 5 points, 2 receiving 3 points, and 2 receiving 2 points. Based on these scores, the fountain pen writing sound received the highest score as the best handwriting sound to use as ASMR, followed by the pencil writing sound by 1 point. The ballpoint pen writing sound received 5 points lower than the pencil writing sound. In particular, the ballpoint pen writing sound, which received the lowest score, had 1 listener who gave it 5 points, showing that personal taste is reflected. Listeners who chose the sound of fountain pen writing, which received the highest score, said that they really liked how the refreshing, crisp sound of the fountain pen nib rubbing against the paper was emphasized. Listeners who chose the sound of pencil writing, which received the second highest score, said they liked the soft, yet moderately crisp, whispering sound of the pencil lead rubbing against the paper when writing with a pencil. Finally, listeners who gave the sound of ballpoint pen writing, which received the lowest score, 5 points, said that they personally liked the soft, crisp sound of the ballpoint pen ball rubbing against the paper.

4. Conclusion

In this study, we analyzed and verified the most popular handwriting sound among ASMR sounds. The handwriting sound varies depending on the writing tool. For this study, we conducted acoustical characteristic research, MOS test, and interviews targeting the writing sounds using representative writing tools such as pencil, fountain pen, and ballpoint pen. The conclusion obtained through this research process was that the fountain pen writing sound received the highest score among the three writing sounds, the pencil writing sound came in second, and the ballpoint pen writing sound came in third. However, all three have characteristics of handwriting sounds, so they were evaluated as good sounds to use as ASMR for each person. The fountain pen writing sound, which received the highest score, was strongly distributed in the low-frequency and high-frequency ranges of the sound of the paper and the fountain pen nib rubbing against each other when writing, and it was said that it is a sound that makes people feel good because it gives a cool and refreshing feeling. The second best opinion was the pencil writing sound, which

evenly distributed low-frequency and high-frequency sounds, so it showed the sound characteristics that soothe people's minds with low-frequency sounds and moderately stimulate people's minds with high-frequency sounds. It was said that it was a sound that everyone felt good about. The ballpoint pen writing sound was similar to the fountain pen writing sound in the low-frequency range of the three writing sounds. However, the high-frequency range was weak, so it produced the softest sound among the three handwriting sounds and was evaluated as suitable for use as ASMR for people who like a soft feeling. Although ASMR sound has not been medically proven, it is an area that affects people. Therefore, since subjective preferences are stronger than objective, you should choose the appropriate sound that suits you. However, ASMR sound is also highly toxic, so if you do not use it appropriately, it is worse than not using it. Therefore, ASMR would suit your psychological state most effectively and soothe your mind only when necessary.

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